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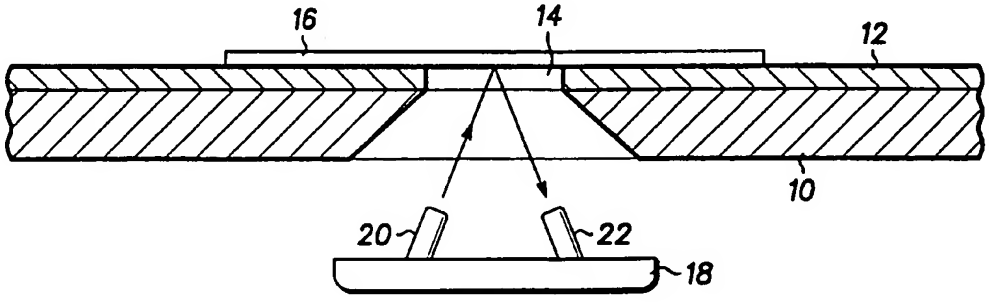
(54) Title: METHOD AND APPARATUS FOR MEASURING A POLISHING CONDITION



(57) Abstract: In a method for determining the condition of the surface, such as thickness or reflectivity, of any specific location on a wafer (16) during a chemical mechanical polishing (CMP), at first, a location of a measurement site on the wafer surface is selected. Second, a picture (22) of the surface within the measurement site is taken, for example, through a window (14). Third, the picture is analyzed. This provides an exact endpointing and an exact final thickness of a specific layer on the wafer.

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METHOD AND APPARATUS FOR MEASURING A POLISHING CONDITION

Field of the Invention

The present invention generally relates to a method and an apparatus for measuring a polishing condition of a surface of an object, and more particularly to a method and an apparatus for measuring a polishing condition of a wafer surface during chemical mechanical polishing (CMP).

Background of the Invention

Integrated circuits are typically formed on substrates, particularly silicon wafers. The integrated circuits are formed by depositing different layers of conducting, semiconducting or insulating nature. After deposition of each layer, features of the electrical circuits are incorporated, e.g. by etching. During the sequential procedure, the upper surface of the substrate becomes more and more non-planar. Thus, the surface of the substrate has to be planarized in order to provide a substantially planar surface.

For example, such planarization can be achieved by chemical mechanical polishing (CMP). In general, during a CMP process a substrate is mounted to a carrier or polishing head. The exposed surface of the substrate is moved against a rotating polishing pad on a polishing platen. A polishing slurry is distributed over the polishing pad. The slurry includes an abrasive component and at least one chemically reactive agent; thus, an abrasive chemical solution is provided at the interface between the pad and the wafer in order to optimize the polishing.

In general, it is desirable to control CMP processes, in order to find an endpoint for polishing or to determine the thickness of a layer.

According to a prior art control process pre and/or post measurement of wafers with either manual or automatic feedback control is performed. Systems are available by which it is possible to measure wet wafers immediately before and after polishing. Due to the monitoring of the condition of the surface before and after polishing it is possible to change the polishing parameters, and therefore, to optimize the polishing during a series production. However, such pre and/or post measurement method bears the disadvantage that the first or the first few wafers have to be polished without optimized parameters - they are polished "blind". Further, during a series production the appearance of the wafers might vary; the pre and/or post measurement method is not capable to consider such variations of the wafers.

In order to find the correct endpoint for polishing several endpointing methods are available. Current methods include measuring temperature, friction, vibration, sonic level, and frequency. Further, various optical measurements are available, e.g. reflectivity measurement methods. Unfortunately, these processes do not work for all substances, in particular when an oxide is polished.

The present invention seeks to provide a method and an apparatus which mitigate or avoid these and other disadvantages and limitations of the prior art.

Brief Description of the Drawings

FIG. 1 is a schematic drawing of a part of a chemical mechanical polishing apparatus according to the present invention;

FIG. 2 shows a part of a wafer;

FIG. 3 shows an enlarged view of a part of Fig. 2; and

FIG. 4 shows a flow-chart diagram of a method according to the present invention.

Detailed Description of the Preferred Embodiment

According to the present invention a method for measuring a polishing condition of a surface of an object comprises the steps of: selecting a location of a measurement site on the surface; taking a picture of the surface within the measurement site; and analyzing the picture, thereby determining the polishing condition of the surface.

According to another aspect of the present invention an apparatus for measuring a polishing condition of a surface of an object comprises: means for selecting a location of a measurement site on the surface; means for taking a picture of the surface within the measurement site; and means for analyzing the picture and for determining the polishing condition of the surface.

Referring to FIG. 1, a polishing platen 10 carries a polishing pad 12. A window 14 is provided in the polishing platen 10 and in the polishing pad 12. On the polishing pad 12 a wafer 16 that is carried by a polishing head (not shown) is positioned. Under the polishing platen 10 an XY stage 18 is provided that carries a light source 20 and a light detector 22.

Different arrangements of the illustrated components are possible. For example, the light source 20 and the light detector 22 may be positioned closer together and/or in different angles to the wafer 16 than illustrated in FIG. 1. Variation of the arrangement may be used to vary the optical properties. Further, it is also possible to position the light source 20 and the

light detector 22 much closer to the wafer 16. This allows application of different polishing methods.

According to a preferred embodiment of the present invention, the surface of the wafer 16 is oriented before it is loaded on the polishing head. A single polishing head or a plurality of polishing heads may be provided.

The rotational and/or translational position of the polishing head may be monitored by a device that may be included on the polishing head or on a shaft of the polishing head. Further, a device may be included on the polishing platen 10 in order to monitor the real time rotational position of the polishing platen 10. Therefore, the real time rotational position of the polishing head, the real time position of the polishing head in any translational motion, and the real time rotational position of the polishing platen 10 is known.

Consequently, it is possible to predict the position of any location on the wafer 16 and its relationship to any point on the polishing platen 10 at any time during the polishing process. This information is used in order to locate a measurement site 24 to be measured within a few millimeters (measurement site 24; FIG. 2 and FIG. 3).

Due to the knowledge of the relative positions of the wafer 16 and of the window 14 in the polishing platen 10 and the polishing pad 12 also a point in time known, by which a measurement site 24 on the wafer 16 is above the window 14. When a measuring site 24 on the wafer 16 is above the window 14 in the pad 12, a picture of the surface of the wafer 16 is taken through the window 14, preferably by using a high resolution digital camera 22. The camera 22 should be a high speed camera 22, since normal polishing processes use fifteen to two hundred revolutions per minute. Thus, in a real time scenario, time is very short in order to take a picture of a

particular measurement site 24. A microscope may also be used as the front end of the optical acquisition system.

In order to obtain a clear picture, the measurement site 24 on the wafer 14 is illuminated by a light source 20.

Preferably, the light source 20 and the light detector 22 are mounted on a small XY stage 18 for fine positioning. The light source 20 and camera 22 can be mounted in any position relative to each other and the wafer 16 that is found to be advantageous.

It is important that the window 14 in the polishing pad 12 is transparent to the wave length of light to be used. Further, the effect of the polishing slurry on the optical behavior has to be considered. In general, it is desirable to use lower wave lengths of light, since such lower wave lengths provide better optical resolution. However, the wave lengths must be compatible with the window material and any chemicals used in the slurry, which has to be considered.

After taking a picture of the part of the wafer 16 predicted to contain the measurement site, the picture is analyzed. For such analyzing, the picture is sent to a computer with pattern recognition software for exact measurement location determination; then, the appropriate pixels of interest are analyzed. The analysis of the pixels provides information e.g. on the reflectivity and on the color. The reflectivity can be used in order to find an endpoint during a metal polishing process; such an endpoint is reached when the reflectivity changes due to the removal of the metal layer. Oxide or nitride layer thickness can be found by determining the color of the area being analyzed.

Many modifications are possible in various embodiments of the present invention. For example, it is possible to measure multiple points on a wafer simultaneously, which

is only limited by the speed of the computer and the video capture.

FIG. 2 shows schematically a typical surface of a wafer 16 to be polished. The regions 26, 28, 30, 32, 34 symbolize different circuitry features on the wafer 16. The numeral 24 designates a measurement site which is to be analyzed during polishing. After taking a picture through the window 14 in the pad 12, this wide field picture is analyzed by a pattern recognition software.

FIG. 3 shows an enlarged view of the measurement site 24. On the basis of the pattern recognition software, a fine alignment can be achieved, and e.g. the colors and intensities of the pixels of interest within a defined area can be recorded. The recorded information is processed as appropriate, including analyzing the spectrum, the rate of color change, the color alone, the intensity, etc.

Thus, a method and an apparatus is provided for measuring any specified point on the wafer including the metrology measurement sites while the process was running. The method and apparatus give an exact endpoint by measuring the actual remaining film thickness or reflectivity of specific structures in real time. Additionally, it should be noted that the apparatus is capable of providing pre and post polishing measurements.

FIG. 4 shows a flow-chart diagram of method 100 for measuring a polishing condition of a surface (e.g., thickness) of an object (e.g., wafer 16).

Method 100 comprises the steps of selecting 110 a location of measurement site 24 on the surface; taking 120 a picture of the surface within measurement site 24; and analyzing 130 the picture to determine the polishing condition of the surface.

Preferably, the step of selecting 110 comprises orienting 112 the surface to be polished; loading 114 the object on a polishing head; and monitoring 116 relative positions of the polishing head.

Preferably, the step of taking 120 a picture comprises providing 122 window 14 in polishing platen 10 (cf. FIG. 1); illuminating 124 the surface through window 14; and taking 125 a digital picture.

Preferably, the step of analyzing 130 comprises determining 132 pixels of interest by using a pattern recognition software (well known in the art, therefore not illustrated); and analyzing 134 the pixels of interest.

Preferably, the step of analyzing 130 comprises determining 136 a reflectivity as the polishing condition, or optionally, determining 138 a color (e.g., of the wafer) as polishing condition.

Preferably, method 100 further comprising the steps of rotating the object; and taking pictures in synchronization with the rotating. Optionally, polishing platen 10 is rotated and pictures are taken in synchronization with the rotating of the platen. Rotating can be combined so that, optionally, method comprises rotating the object and the polishing platen; and taking pictures in synchronization with the rotating.

As mentioned above, the step of selecting preferably comprises monitoring a real time rotational position of the polishing head; monitoring a real time translational position of the polishing head; and monitoring a real time rotational position of the polishing platen.

While the invention has been described in terms of particular structures, devices and methods, those of skill in the art will understand based on the description herein that it is not limited merely to such examples and

that the full scope of the invention is properly determined by the claims that follow.

CLAIMS

1. A method for measuring a polishing condition of a surface of an object, comprising the steps of:
selecting a location of a measurement site on said surface;
taking a picture of said surface within said measurement site; and
analyzing said picture, thereby determining said polishing condition of said surface.

2. The method according to claim 1 wherein said step of selecting comprises:
orienting said surface to be polished;
loading said object on a polishing head; and
monitoring relative positions of said polishing head.

3. The method according to claim 1 wherein said step of taking a picture comprises:
providing a window in a polishing platen;
illuminating said surface through said window; and
taking a digital picture.

4. The method according to claim 1 wherein said step of analyzing comprises:
determining pixels of interest by using a pattern recognition software; and
analyzing said pixels of interest.

5. The method according to claim 1 wherein said step of analyzing comprises determining a reflectivity as said polishing condition.

6. The method according to claim 1 wherein said step of analyzing comprises determining a color as said polishing condition.

7. The method according to claim 1 further comprising the steps of:
rotating said object; and
taking pictures in synchronization with said rotating.

8. The method according to claim 1 further comprising the steps of:
rotating said polishing platen; and
taking pictures in synchronization with said rotating.

9. The method according to claim 1 further comprising the steps of:
rotating said object and said polishing platen; and
taking pictures in synchronization with said rotating.

10. The method according to claim 1 wherein said step of selecting comprises:
monitoring a real time rotational position of said polishing head;
monitoring a real time translational position of said polishing head; and
monitoring a real time rotational position of said polishing platen.

11. An apparatus for measuring a polishing condition of a surface of an object, comprising:
means for selecting a location of a measurement site on said surface;
means for taking a picture of said surface within said measurement site; and
means for analyzing said picture and for determining said polishing condition of said surface.

12. The apparatus according to claim 11, further comprising:
means for orienting said surface to be polished;
a polishing head;
means for loading said object on said polishing head;
means for monitoring relative positions of said polishing head.

13. The apparatus according to claim 11, further comprising:
a polishing platen having a window;
means for illuminating said surface through said window; and
means for taking a digital picture.

14. The apparatus according to claim 11, further comprising:
a pattern recognition software for determining pixels of interest; and
means for analyzing said pixels of interest.

15. The apparatus according to claim 11, further comprising means for determining a reflectivity as said polishing condition.

16. The apparatus according to claim 11, further comprising means for determining a color as said polishing condition.

17. The apparatus according to claim 11, further comprising:
means for rotating said object; and
means for taking pictures in synchronization with said rotating.

18. The apparatus according to claim 11, further comprising:
means for rotating said polishing platen; and
means for taking pictures in synchronization with said rotating.

19. The apparatus according to claim 11, further comprising:
means for rotating said object and said polishing platen; and
means for taking pictures in synchronization with said rotating.

20. The apparatus according to claim 11, further comprising:
means for monitoring a real time rotational position of said polishing head;
means for monitoring a real time translational position of said polishing head; and
means for monitoring a real time rotational position of said polishing platen.

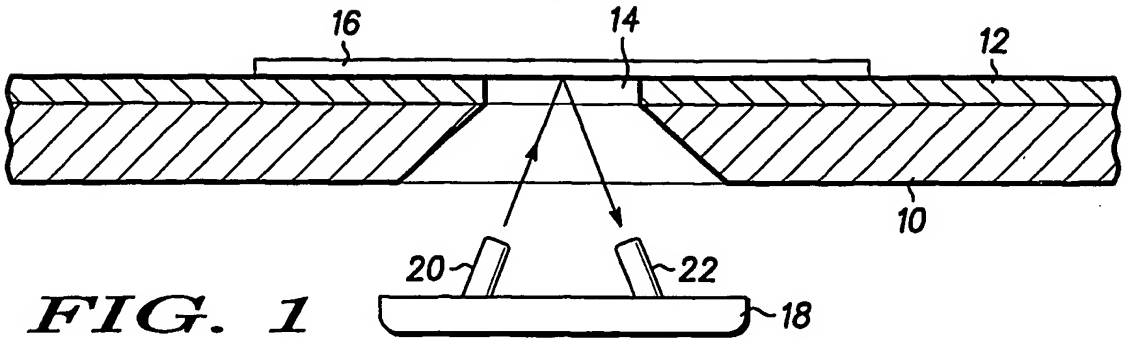


FIG. 1

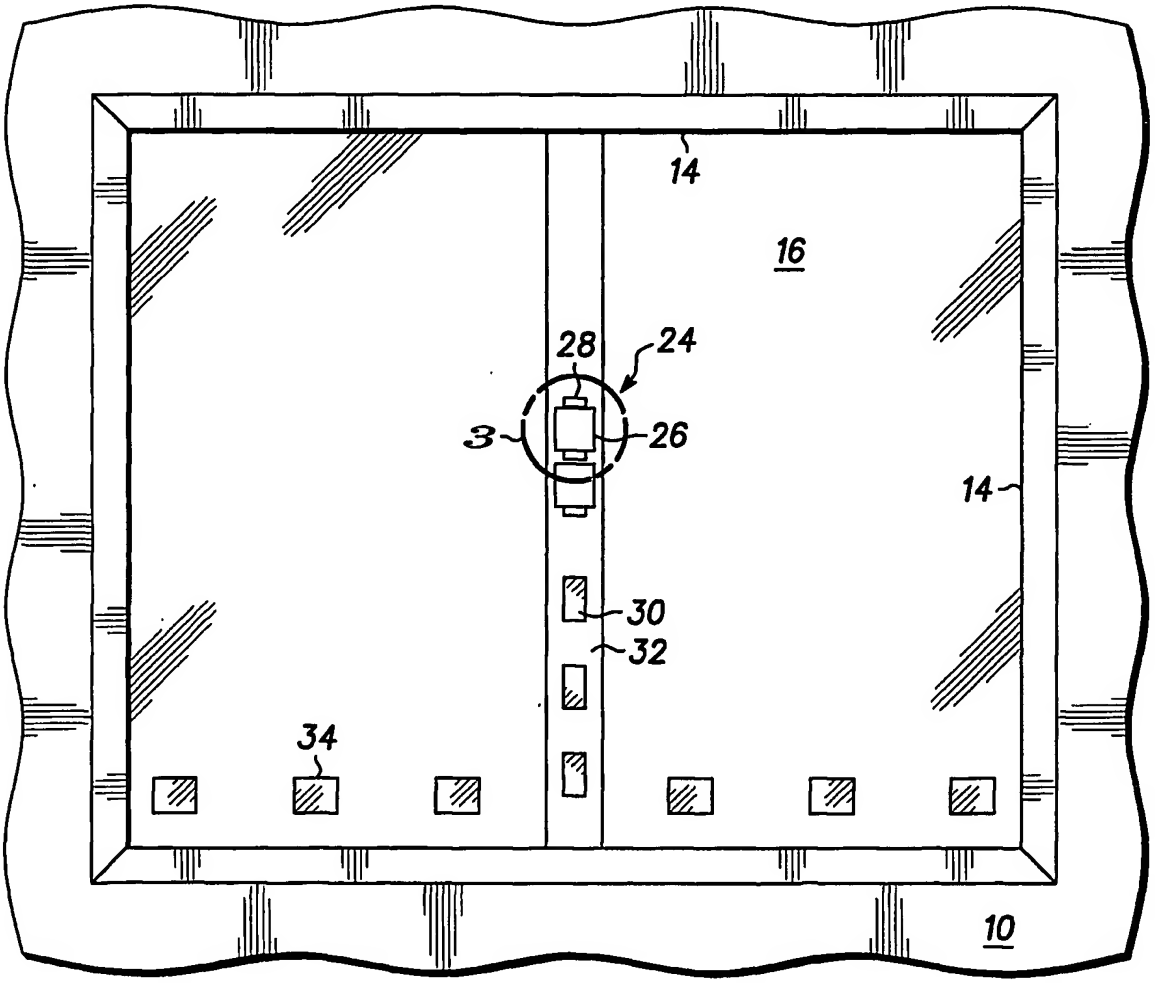


FIG. 2

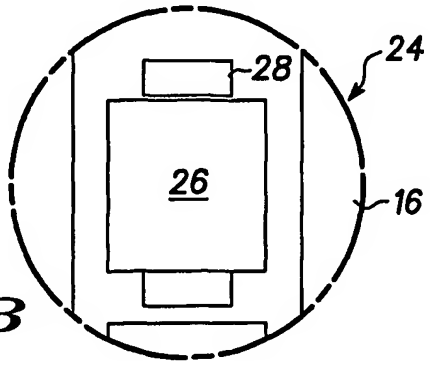
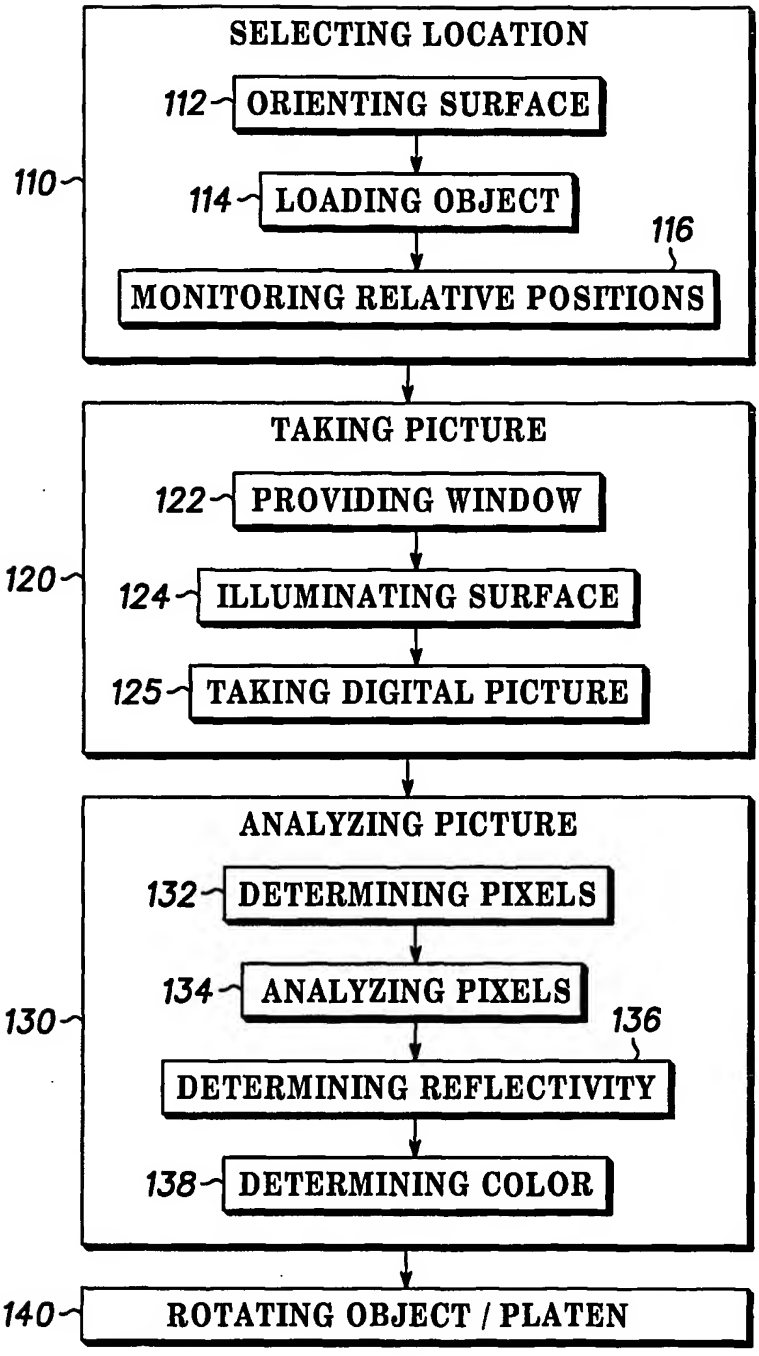


FIG. 3


SELECTING LOCATION
112
ORIENTING SURFACE
110
114
LOADING OBJECT
116
MONITORING RELATIVE POSITIONS
TAKING PICTURE
122
PROVIDING WINDOW
120
124
ILLUMINATING SURFACE
125
TAKING DIGITAL PICTURE
ANALYZING PICTURE
132
DETERMINING PIXELS
134
ANALYZING PIXELS
130
136
DETERMINING REFLECTIVITY
138
DETERMINING COLOR
140
ROTATING OBJECT / PLATEN

100

FIG. 4